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Record-keeping systems adoption by Louisiana dairy farmers

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RECORD-KEEPING SYSTEMS ADOPTION BY LOUISIANA DAIRY FARMERS

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ABSTRACT

Fifty Louisiana dairy farmers were interviewed to gather production amounts, costs of production, management techniques, technologies adopted, and demographic information. These data were used to analyze what record-keeping systems the farmers were adopting and to what extent the systems were being used. Logit, ordered probit, negative binomial regression, OLS regression, and double hurdle models were used to determine adoption and intensity.

In this study, age was found to decrease the probability that a farmer would believe their computer was not at all useful and also of limited usefulness, while increasing the probability that a farmer would believe the computer was very useful to the farm business. Older farmers were more likely to perceive the computer as more useful.

Having a family successor to take over the dairy upon the operator's retirement affected many things, including: decreasing experience with the internet; increasing the probability of a farmer perceiving the computer as of limited usefulness; decreasing the probability of a farmer perceiving the computer as very useful; increasing the hours spent per week reviewing DHIA output; increasing the number of financial measures tracked; increasing the intensity of use of DHIA after it has been adopted; and increasing the probability of adopting computerized record-keeping systems.

If the operator himself kept the records for the farm, then fewer financial statements were generated and less time was spent updating computerized record-keeping systems. These farmers, however, devoted more time to reviewing DHIA output.

When the farmer was a technology adopter he was more likely to have experience with the internet and to have adopted DHIA, but spend less time reviewing DHIA output. Also, technology adopters were more likely to view the computer as very useful and less likely to view the computer as not at all useful.

The more statements a farmer generated for financial analysis, the more likely he was to adopt computerized record-keeping systems. Thus, farmers with a greater interest in record-keeping were likely to find the computer more useful because it can make financial analysis much easier compared to paper based records.

CHAPTER 1: INTRODUCTION

A. General Introduction

This study will examine the adoption rates of several technologies (including computerized records, DHIA production records and internet technologies) by dairy farmers in Louisiana. This study will determine which farmers are adopting the technologies and to what extent they are adopting the technologies.

This study focuses on record-keeping systems because of their importance to farm management and their relative ease of adoption. Without an accurate idea of what is happening on the farm, farmers cannot make the best decisions that will lead to maximum profit (or utility). If farmers do not know their break-even point or have a good idea of their financial standing, they might stay in production for too long, accumulate large amounts of debt, and have to sell out at a later point, therefore losing much of the equity they had accumulated in their farm assets.

Production records are important since farmers base many of their everyday decisions on these figures. For example, dairy farmers need to know what daily production level they should not drop below before drying up a cow, so as to not waste feed and other inputs on a cow that is producing less value than she is consuming. They also need to know which cow and bull combinations result in the most productive offspring, and the optimum time to breed cattle.

B. Specific Record-Keeping Technologies under Analysis

Production Record-Keeping Technologies

Some of the different types of production record-keeping systems included in this analysis are Excel or other basic spreadsheets, DHIA (Dairy Herd Improvement Association), milk tickets, hand written records, or the lack of records. Milk tickets are receipts that are mailed out to the producers (or posted online) at certain times of the year to inform the farmers how much milk they shipped during a specific time period. Some farmers just write down their production figures from weigh jugs and other cattle maintenance records in a notebook or ledger and simply refer back to their figures when they need the information again. Weigh jugs are simply containers that farmers can use to measure the milk produced from each cow. Other farmers retain all information via memory, which causes one to question how much information can be stored and recalled correctly.

<u>DHIA Records</u>

The DHIA offers a service that some dairy farmers choose that helps them track their production and cattle management information. The DHIA is composed of several individual regional and state nonprofit associations governed by boards of directors composed of dairy farmers. Therefore, the associations try to provide the best services possible while keeping costs for the farmers as low as possible. There is a National DHIA which monitors the testing procedures preformed by the individual associations and collects and assembles data for USDA and National Agricultural Statistics Service (NASS) (Hay, March 21, 2007).

Every thirty, forty-five, sixty, or another other interval chosen by the farmer, days, a technician will visit the dairy farm and take samples from the day's milk production. The samples are analyzed to determine the amount and quality of milk for each individual cow. This data is then sent to a processing center (Louisiana DHIA uses a processing center in North Carolina) to be analyzed. Then the data is either mailed out to the farmer in a paper report form or sent to the farmer to develop their own reports using the PC Dart software (Hay, March 21, 2007).

PC Dart allows farmers to do four things: one, view several herd summary reports (such as milk production and calving intervals); two, farmers can generate their own reports on whatever they find useful; third, farmers can track the health and production of individual cows; and fourth, farmers can create protocols which are action lists. For example, if 50 cows needed to be vaccinated in the following week, the farmer could select the cows and create the report and their employees could view the report and perform the necessary actions (Hay, March 21, 2007).

In Louisiana, it is estimated that 70 farmers (or about one third of the dairy farmer population) use DHIA. The DHIA Louisiana director believes that the use of DHIA improves output by 4000 lbs of milk per cow per year due to farmers having better management information (Hay, March 21, 2007). The cost of DHIA services is dependent upon the testing interval, number of cows tested, whether the farmer collects the samples or if this is done by a field technician and whether the farmer wants laboratory analysis (Hay, March 21, 2007).

Financial Record-Keeping Technologies

Computerized farm financial record-keeping systems are relatively straightforward to adopt since computers and software are so readily available. They can be used by almost any type of farmer in any geographic area, producing any commodity or mix of commodities. Even with all of these advantages many farmers are not adopting computerized farm financial record-keeping systems because they can be viewed as very intimidating and hard to set-up.

The computerized financial record-keeping systems under analysis in this study include software programs such as Excel and other general spreadsheet programs, pre-designed bookkeeping software packages, hand written records, and the lack of formal records. Blank spreadsheet programs can be used for much more than just accounting information, but it takes substantial time and effort to design a spreadsheet to meet all of the needs of a farm business. Pre-designed bookkeeping software products come ready to do many accounting functions such as entering checks and bills and generating financial statements. Such software, however, is rather expensive, requires significant training, and the accounts, suppliers, customers, and vendors have to be entered before use. Hand written records are easy to lose and damage. Also, they are not always complete and are often not detailed.

C. U.S. and Louisiana Dairy Industries

Why Louisiana dairy farmers? This industry typifies what the American public has thought of when hearing about family farms for many years. In many cases, these dairy farms have been in production for several generations and almost all of the dairy farmers were raised on the dairy farm, learning about dairy production. Most of the farmers know all of their cows by sight (if not by name).

Louisiana dairy farmers have exited the industry rapidly in recent years. Dairy farmers have been facing slowly rising nominal milk prices, while facing rapidly rising fuel costs (dairy cooperatives charge producers hauling costs) along with higher fixed costs like equipment prices and increasing land values. Also, similar to the general trend of all of the major U.S. agricultural commodities, the U.S. dairy industry is consolidating (see USDA, NASS 1966, 1976, 1986, 1996, and 2006). Smaller farms are being squeezed out of business because larger farms with more production units can survive on lower prices than the smaller "family farms."

Hurricane Katrina created additional problems for the dairy industry in southeast Louisiana. The loss of power caused many farms to have to dump milk they could not keep cool, and roads being blocked with debris delayed milk pickups, which led to more milk dumping and lost income (Herndon, 2006). Dairy farmers also had difficulties getting dairy feed, and ryegrass planting was delayed because of a drought after Hurricane Katrina (Herndon, 2006). So, many farms were left with the choice to make costly repairs to their fences, buildings, and equipment or exit the dairy industry. For many farmers, Hurricane Katrina may have been the final blow that forced them out of production.

Why is this important? Even today, agriculture students still study Thomas Jefferson's agrarianism values from the 1700s:

- Agriculture is the basic occupation of mankind,
- Rural life is morally superior to urban life, and
- A nation of small, independent farmers is the proper basis for a democratic society.

(Knutson, Penn and Flinchbaugh, 2004). So it is very troubling to see farmers giving up their way of life. Therefore, this study will attempt to guide farmers as to what new technologies they could adopt to help improve their production and therefore stay in dairy production longer.

D. Change in the Louisiana and U.S. Dairy Industries

How many dairy farms have exited the industry and how have production levels changed over the past forty years? Table 1.1 provides data to answer this question. For the United States as a whole, pounds of milk per cow per year increased from 8,080 in 1965 to 19,576 lbs in 2005 (USDA, NASS 1966, 1976, 1986, 1996, and 2006). Thus, production efficiency, measured as total output per cow, more than doubled over the past forty years. On the other hand, the total number of cows in the United States dropped from 15,477,000 cows in 1965 to 9,041,000 in 2005 (USDA, NASS 1966, 1976, 1986, 1996, and 2006). The reduction in the total number of cows has been more than compensated for by the increase in production per cow.

Table 1.1. U.S. Number of Dairy Cows and Annual Milk Production per Cow.

	2005	1995	1985	1975	1965
Cows	9,041,000	9,461,000	11,025,000	11,151,000	15,477,000
Lbs/milk/cow	19,576	16,451	13,031	10,354	8,080

Similar, though more dramatic trends have occurred in the Louisiana dairy industry as shown in Table 1.2 and Figure 1.1. In 1965, there were 203,000 dairy cows in the state. This dropped to 35,000 in 2005 (USDA, NASS 1966, 1976, 1986, 1996, and 2006). The advances in production efficiency are similar to what happened in the entire U.S.; however, Louisiana production still lags behind the national average. In 1965, Louisiana production per cow was 4,900 lbs. It increased to 12,371 lbs per cow in 2005 (USDA, NASS 1966, 1976, 1986, 1996, and 2006). The 12,371 lbs per cow per year milk production lags behind the national average of 19,576 lbs of milk per cow per year.

Table 1.2. Louisiana Number of Dairy Cows and Annual Milk Production per Cow.

	2005	1995	1985	1975	1965
Cows	35,000	79,000	96,000	136,000	203,000
Lbs/milk/cow	12,371	11,456	9,490	7,750	4,900

There are reasons for this lag in Louisiana's production efficiency: in hot summer weather, the cows cannot produce as much milk. The combination of heat and humidity has been shown to reduce daily milk production in Holstein and Jersey cattle (Bianca, 1965). Holsteins at 29°C and 40% relative humidity reduced their daily milk production to 97% of normal output, while under the same conditions Jerseys reduced their production to 93% of normal output. When the relative humidity was increased to 90%, yield for the Holsteins dropped to 69% and Jerseys dropped to 75% of normal levels (Bianca, 1965). A second reason for lower productivity is that most Louisiana dairy farms are "pasture-based," which generally results in lower milk yields, but also lower cost (Taylor and Foltz, 2006).

This study will determine which factors affected whether or not farmers adopted record keeping technologies and their intensity of use. While there have been recent studies on farmers' adoption of computers (Gloy and Akridge, 2000; Hoag, Ascough, and Frasier, 1999; and Jofre-Giraudo, Streeter, and Lazarus, 1990), none of these studies have focused on whether or not Louisiana dairy farmers are adopting computers or whether they are using the computers for farm decisions.

Also under consideration in this study are the factors that lead farmers to closely examine their financial positions, through tracking ratios and preparation of financial statements.

Furthermore, this study will examine what affects farmers' perceived usefulness of their computer systems, how often they update their records, and how many hours they spend each week reviewing their DHIA and financial output.

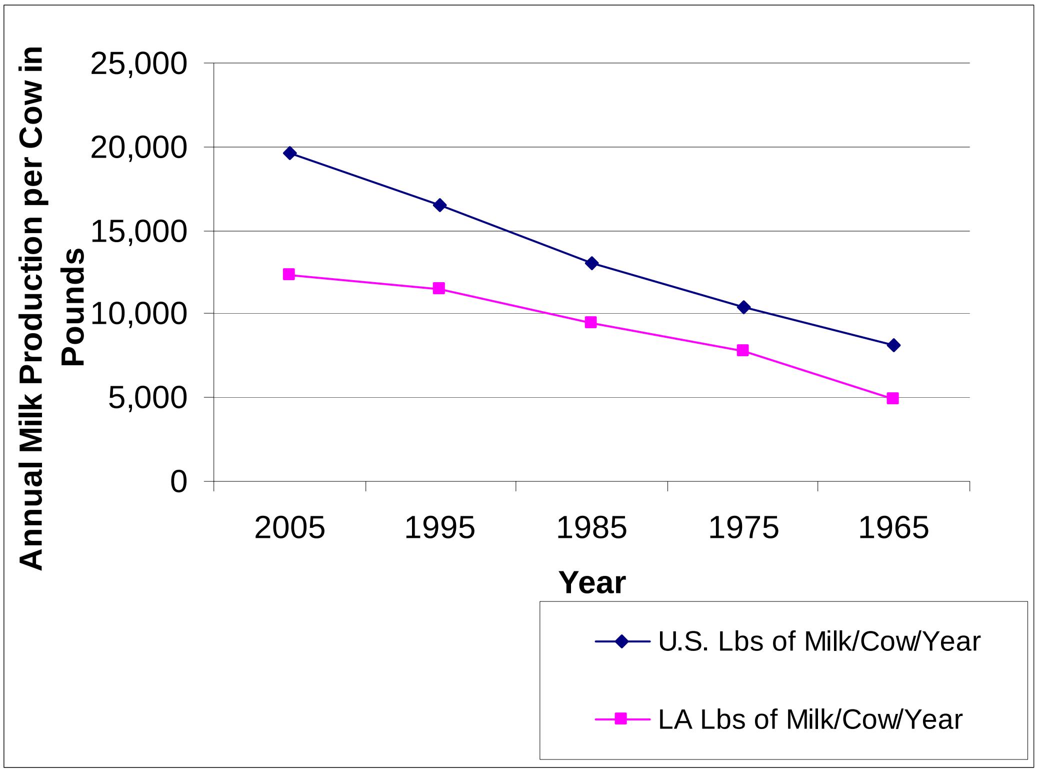

Figure 1.1. U.S. and Louisiana Annual Milk Production per Cow

E. Justification

Are record-keeping practices important enough to warrant this in-depth study? According to Jackson-Smith, Trechter, and Splett (2004), return on assets was improved if the farmer simply calculated and tracked annual cost of production in the Wisconsin dairy industry.

F. Objectives

The objectives of this study are to determine for Louisiana dairy farmers:

1. what technologies are being adopted by farmers,
2. which types of farmers are adopting technologies,
3. how useful computer technologies are perceived to be,

4. which farmers are more likely to see computer technologies as useful,

5. to what detail farmers are tracking their production and financial information, and

6. the intensity of use of new technologies.

G. General Procedures and Outline of Thesis

After the introduction to the study in Chapter 1, Chapter 2 will cover previous adoption studies dealing with technology adoption in general, the adoption of computer technologies, and the impact of adoption on efficiency. Chapter 3 will discuss the data, models, and explanatory variables used in this study. Chapter 4 will present the analysis results, and finally Chapter 5 will summarize the study including important findings, limitations of the current study, and suggestions for future research.

CHAPTER 2: LITERATURE REVIEW

A. Technology Adoption in General

A wide variety of technology adoption articles have been published in the agricultural economics journals. The main reason for so many articles is likely that there are many different technologies to study in many different segments of the farming industry. New technologies range from growth hormones, production hormones, reproductive hormones, genetically modified organisms, to technologies such as computer and internet technologies, and new software packages such as Global Information Systems software (GIS).

Perhaps the most widely recognized technology adoption paper is Feder, Just and Zilberman's (1985) survey of papers up to that date dealing with agricultural technology adoption in developing countries. The authors discussed factors that influence the adoption of new technologies, including farm characteristics, risk and uncertainty, human capital, labor availability, credit constraints, land tenure, and supply constraints. The present study will examine these factors to see which have significant effects on technology adoption by farmers and production efficiency.

What is technology adoption and how does it typically occur? Rogers (1962) defined technology adoption as "the mental process an individual passes from first hearing about an innovation to final adoption." Final adoption at the individual farmer level is defined as:
"the degree of use of a new technology in long run equilibrium when the farmer has full information about the new technology and its potential" (Feder, Just, and Zilberman, 1985). The shape of the adoption curve is usually found to be a logistic or s-shaped curve, where adoption is slow at first, then increases at an increasing rate, then increases at a decreasing rate, and finally levels off (Griliches, 1957).

Several papers have studied the adoption of rBST in different segments of the dairy industry (Klotz, Saha, and Butler, 1995; and Barham et al., 2004). Others have tried to explain why technology is sometimes so slow to be adopted (Shields, Rauniyar, and Goode, 1993). These papers have looked at several reasons why specific technologies were adopted. In contrast, the present study will address if there is sufficient motivation (higher production) for farmers to adopt new technologies.

Gillespie, Davis, and Rahelizatovo (2004), Rahelizatovo and Gillespie (2004), Barrett et al. (2004), and Zepeda (1994) all found that risk aversion plays a major role in the decision to adopt technologies. People who are risk averse are more likely to adopt technologies that reduce risk and likewise less likely to adopt technologies that increase risk.

Labor quality and availability have been found to affect adoption decisions. Many technologies that are yield improving are not adopted because farmers do not have available labor to harvest more product (Feder, Just, Zilberman, 1985). Another issue is many farmers feel they must watch over hired labor closely to prevent agency problems (i.e. theft, work productivity, and abuse of equipment). Gillespie, Davis, and Rahelizatovo (2004), Zepeda (1994), and Shields, Rauniyar, and Goode (1993) have examined the effects of labor availability and how quality affects the probability of technology adoption.

Levels of higher education and farm size have been found to increase the probability of technology adoption by: Rahelizatovo and Gillespie (2004) in the adoption of best management practices (BMPs); Rahm and Huffman (2001) in the adoption of reduced tillage practices; Saha, Love, and Schwart (2001) in the adoption of rBST by dairy farmers; Barrett et al. (2004) in the adoption of rice growing technologies by Malagasy farmers; Barham et al. (2004) in the adoption of rBST by Wisconsin dairy farmers; Zepeda (1994) in the adoption of DHIA by dairy farmers;

and Shields, Rauniyar, and Goode (1993) in the adoption of recommended planting and fertilizing practices.

Farm size is another factor that has been repeatedly shown to increase the probability of technology adoption. Which studies have shown that larger farm sizes increase adoption? They include Gillespie, Davis, and Rahelizatovo (2004) in the adoption of hog breeding technologies; Rahelizatovo and Gillespie (2004) in BMP adoption; Rahm and Huffman (2001) in the adoption of reduced tillage practices; Saha, Love, and Schwart (2001) in the adoption of rBST; Barrett et al. (2004) in the adoption of rice growing technologies by Malagasy farmers; Barham et al. (2004) in the adoption of rBST by Wisconsin dairy farmers; Zepeda (1994) in the adoption of DHIA by dairy farmers; Shields, Rauniyar, and Goode (1993) in the adoption of recommended planting and fertilizing practices; and Klotz, Saha, and Butler (1995) in the adoption of rBST.

Production per unit or yield (milk/cow/year or bushels/acre) has been found to have positive and significant relationships with the probability of technology adoption by Rahelizatovo and Gillespie (2004) in BMP adoption; Klotz, Saha, and Butler (1995) in the adoption of rBST; and Zepeda, (1994) in the adoption of DHIA by dairy farmers. Conversely, age has been found to have a negative relationship with the probability of technology adoption by: Rahelizatovo and Gillespie (2004) in BMP adoption; Barham et al. (2004) in the adoption of rBST by Wisconsin dairy farmers; and Zepeda (1994) in the adoption of DHIA by dairy farmers.

Credit availability affects technology adoption decisions. If credit is readily available, more technologies will be adopted, especially if the technology is a large, indivisible unit. This relationship was found by Barrett et al. (2004) in the adoption of rice growing technologies by Malagasy farmers, and Zepeda (1994) in the adoption of DHIA by dairy farmers.

Positive prior technology adoption increases the probability of technology adoption, as found by Saha, Love, and Schwart (2001) and Klotz, Saha, and Butler (1995) in the adoption of rBST by dairy farmers. Zepeda (1994) examined the relationship between record-keeping and experience and found a quadratic relationship, which means that as one grows older, records are more useful until the farmers became very experienced, at which point they choose not to use records.

Other factors that have been found to affect the probability of technology adoption include farm diversification, debt to asset ratio (Gillespie, Davis, and Rahelizatovo, 2004, in the adoption of hog breeding technologies); DHIA usage (Rahelizatovo and Gillespie, 2004, in the adoption of BMPs); conferences and extension services usage (Rahm and Huffman, 2001, in the adoption of reduced tillage practices; Zepeda, 1994 in the adoption of DHIA; Barrett et al., 2004, in the adoption of rice growing technologies by Malagasy farmers); experience (Rahm and Huffman, 2001, in the adoption of reduced tillage practices; Zepeda, 1994, in the adoption of DHIA); age and plans to expand (Saha, Love, and Schwart, 2001, in the adoption of rBST by dairy farmers); farmer management ability and technology use by peers (Barham et al., 2004, in the adoption of rBST by dairy farmers); capital availability (Shields, Rauniyar, and Goode, 1993, in the adoption of recommend farming practices) and land tenure (Rahelizatovo and Gillespie, 2004, in the adoption of BMPs; Zepeda, 1994, in the adoption of DHIA; and Rahm and Huffman, 2001, in the adoption of reduced tillage practices).

B. Computer and Record-Keeping System Adoption

While some work has been done on technology adoption by Louisiana farmers and, more specifically, Louisiana dairy producers (Gillespie, Davis, and Rahelizatovo, 2004; Rahelizatovo and Gillespie, 2004), studies are lacking about the adoption of computerized record-keeping systems in Louisiana. Jarvis (1990) studied computer adoption by Texas rice producers; Baker (1992) studied computer adoption by non-farm agribusinesses in New Mexico; Hoag, Ascough, and Frasier (1999) studied computer adoption by farmers in the Great Plains; Putler and

Zilberman (1988)studied computer use in Tulare County, California; Gloy and Akridge (2000) analyzed computer and internet adoption on large U.S. farms; and Amponsah (1995) looked at computer adoption and usage of information services by North Carolina farmers.

Iddings and Apps (1990) studied farmers in Wisconsin and Kansas to determine which factors influenced computer usage by farmers and had findings similar to many of the previously mentioned technology adoption papers. They found that complexity of the farm increased the need for computers, but that older farmers were less likely to adopt computer technology. Hoag, Ascough, and Frasier (1999) used experience instead of age and found that each year of experience reduced the probability of adoption by 1.76% in the adoption of a farm computer. Putler and Zilberman (1988) found that the number of farm enterprises did not affect the probability of adoption of a computer. They did find age to affect adoption: probability of adoption increased with age up until age 40, and then it decreased. The same result was found by Gloy and Akridge (2000) with computer and internet adoption.

In studies by Hoag, Ascough, and Frasier (1999) and Amponsah (1995), farm size was found to be significant and had a positive relationship with the probability of adopting computer technology. In an earlier study, Putler and Zilberman (1988) also found larger farm sizes led to higher probabilities of adoption of computers, but they also found diminishing marginal effects of farm size on adoption. Jackson-Smith, Trechter, and Splett (2004) found that farm size increased the probability of participation in a special program that closely analyzed the farm's financial performance, and also that larger farms had higher return on asset ratios. Baker (1992) studied non-farm agribusinesses in New Mexico and found firm size to have a positive and significant relationship with the probability of adopting computer technologies.

Putler and Zilberman (1988), Gloy and Akridge (2000), and Amponsah (1995) found that higher education led to higher probabilities of computer adoption. These results were further supported by Hoag, Ascough, and Frasier (1999) who found that farmers with some college classes or a bachelor's degree were significantly more likely to adopt computers (30% more likely than those with only a high school education).

Some other factors found to influence the adoption of computer technologies by farmers include the degree of external support and network of computer users the farmer is familiar with (Iddings and Apps, 1990); the ownership of a non-farm business, off-farm employment, and peer's computer use (Doye, 2004); management skills and computer familiarity (Jarvis, 1990); the presence of teenagers in the house (Mishra and Williams, 2006); land tenure (Hoag, Ascough, and Frasier, 1999); and income and formal farm record-keeping systems (Amponsah, 1995).

Computerized record keeping systems are mainly considered to be management-intensive technologies. El-Osta and Morehart (1999) found several differences between what factors affected the adoption of capital-intensive versus management-intensive technologies, as well as combined management and capital-intensive technologies. Age, size, and dairy specialization increased the likelihood of adopting a capital-intensive technology. Education and size positively increased the likelihood of adopting a management-intensive technology. Age, education, credit, size and increased usage of hired labor increased the probability of adopting a combined management and capital-intensive technology. In a later study, El-Osta and Morehart (2000) found that size had a positive relationship (with diminishing marginal returns) with the probability of adopting a capital-intensive technology.

Zepeda (1994) also found higher production/cow to increase the probability of adopting record-keeping systems such as DHIA. The author explained it by saying that there was a higher payback to information as production per cow increased. Another reason is that more production means more units to spread the fixed cost of record adoption over, thereby making it more attractive to farmers with higher production.

C. The Effect of Technology Adoption on Production and Efficiency

What has been shown to increase production? Foltz and Chang (2002) found education to increase milk production. They also found participation in DHIA (or another similar program) to increase milk output per cow per year by 3,202 lbs. Zepeda (1994) found DHIA participation to increase production by 783 pounds of milk per cow per year, a much lower amount than found by Foltz and Chang (2002). Ahmad and Bravo-Ureta (1996) found increasing the amount of concentrates fed per cow increased technical efficiency. Weersink and Tauer (1991) found that high feed prices reduced the amount of concentrates fed, which in turn reduced milk production per cow.

Profitability is an important factor in a farm's long-term ability to remain in operation. Gloy, Hyde, and LaDue (2002) attribute the shrinking number of farms (in all areas of commodity production) to the fact that only the most profitable farms are able to stay in business and their profitability allows them to expand production.

What has been done to determine which farmers are the most profitable and how they are producing profitably? Fane (1975) found farmers with higher levels of education were able to produce milk closest to the theoretical average minimum cost point, thereby making them more profitable. Milk production per cow has been shown to be positively correlated with various measures of financial position (Sonka, Hornbaker, and Hudson, 1989; Short, 2000; El-Osta and Johnson, 1998; Ford and Shonkwiler, 1994).

There have been several studies analyzing the relationship between farm size and profitability. Some show that farm size is positively related to profitability (Cocchi, Bravo-Ureta, and Cooke, 1998; El-Osta and Johnson, 1998; Mishra and Morehart, 2001; Short, 2000;

Ford and Shonkwiler, 1994). On the other hand, Kauffman and Tauer (1986) and Tauer and Stefanides (1998) showed that farm size was not a significant factor in profitability. Foltz and Chang (2002) found that farm size was positively related to profit but with diminishing marginal returns.

Mishra, El-Osta, and Johnson (1999) found that formal record-keeping systems increased farm profitability. Even though computers and software are not divisible, they are not very expensive considering the impact that they can have on farm profitability. Also, after the initial learning phase, computers can save farmers time by having all the accurate and organized information they need at hand.

Jofre-Giraudo, Streeter, and Lazarus (1990) found that computerized management information systems (MIS) improved the accuracy, speed, and timeliness of information for processing, which improved the management decision-making process. They also found that records were updated on a more timely basis and records were kept at a higher level of detail when using MIS. This more accurate and timely data allowed more farmers to project their financial condition on a monthly basis, which could help farmers reevaluate their production and financial situations quickly so that changes in management could be implemented, if necessary.

CHAPTER 3: METHODOLOGY AND DATA COLLECTION

A. Data

This study uses primary data gathered from personal interviews to collect information on milk production, production costs, record-keeping activities, technologies adopted, and general farm and farmer statistics. The population selected for study was Louisiana dairy farmers (concentrated mostly in St. Helena, Washington and Tangipahoa parishes). A list of dairy farmers was obtained from the state sanitation board which included the entire population of 310 dairy farmers, as of July 2005. Of the 310 farmers, 75 were randomly selected using a random number generator in Excel. These farmers were sent a letter describing the interview and why it was being conducted. A few days later, they were called and asked if they would allow the interviewer to come out to their farm and conduct the interview. If so, a time was scheduled for the interview, which normally lasted about an hour and a half. Once those 75 were contacted, another 47 were drawn using the random number generator. This continued until all 310 had been contacted in groups of 32 to 50. Letters were not mailed to all farmers at once because the enumerators could only complete three or four surveys each week, and they did not want the farmers to receive the letter and not be able to promptly schedule an interview if they were willing. The surveys were conducted during the months of January though May 2006.

The survey questions were compiled from literature reviews and past surveys that were conducted to update the state dairy budgets. Other questions were taken from previous beef cattle surveys conducted by the LSU Agricultural Center. Appendix One includes a copy of the survey instrument. Appendix Two includes a copy of the actual letter that was sent to the producers to request an interview.

B. Models

Logit Analyses

Logit analyses using STATA were used to determine the types of farmers that adopted computerized record-keeping systems and participated in the Dairy Herd Improvement Association. Factors such as: farm size, farm diversification, farmer characteristics, successor availability, labor availability, and others were analyzed to determine whether they had impacts on the adoption of the technologies. The specific independent variables used in these models are listed and defined later in this chapter in Section C: Explanatory Variables. The logit model is:

$$PROB(Y=1) = \frac{e^{\beta' x}}{1+e^{\beta' x}} = \Lambda(\beta' x). \qquad (3.1)$$

where the set of parameters β reflects the impact of changes in x on the probability of adoption (Greene, 2000).

For continuous variables, the marginal effects are given by:

$$\frac{dE[y/x]}{dx} = \Lambda(\beta' x)[1-\Lambda(\beta' x)]\beta, \qquad (3.2)$$

For dummy variables, the marginal effects are calculated as:

$$PROB[Y=1|\bar{x}_{(d)}, d=1] - PROB[Y=1|\bar{x}_{(d)}, d=0] \qquad (3.3)$$

(Greene, 2000).

Questions Analyzed Using a Logit Model

Two questions were analyzed using logit models. They are:

- Is your record keeping system manual or computer based? (Computer = 1, Manual = 0).

- Answer to the question asking whether the farmer had positive, negative, or no experience with the internet. (Positive or Negative (indicating some experience) =1, No Experience=0).

The logit model was used for these questions because technology adoption is a yes or no decision (coded as 0 or 1) and the logit model allows analysis of what important factors (like farm and farmer characteristics) affect the adoption decision. Also, technology adoption rates over time have been shown to be consistent with an S-shaped logistics curve, (Griliches, 1957) which is the basis from which the logit model is derived.

Shields, Rauniyar, and Goode (1993) used logit models to describe what influenced farmers' adoption decisions for improved seeds, tractor plowing, basal fertilizer, and topdressing fertilizer. Soule, Tegene, and Wiebe (2000) used a logit model to test the effect of land tenure on the adoption of conservation practices. Gloy and Akridge (2001); Amponsah (1995); Putler and Zilberman (1988); Jarvis (1990); Baker (1992); and Hoag, Ascough, and Frasier (1999) used logit models to determine what farmer and farm characteristics affected the adoption of computers and the internet.

<u>Ordered Probit Analyses</u>

Ordered probit analyses using STATA were conducted to determine the factors influencing how frequently farmers updated their record systems and what factors affected the farmer's perceived usefulness of their computer system. The probabilities of falling into ordered categories 0,1, 2… J are given by the following:

$$
\begin{aligned}
&PROB(y=0) = \Phi(-\beta' x), \\
&PROB(y=1) = \Phi(\mu_1 - \beta' x) - \Phi(-\beta' x), \\
&PROB(y=2) = \Phi(\mu_2 - \beta' x) - \Phi(\mu_1 - \beta' x), \\
&. \\
&. \\
&. \\
&PROB(y=J) = 1 - \Phi(\mu_{J-1} - \beta' x).
\end{aligned}
\tag{3.4}
$$

where the μ's are unknown threshold parameters to be estimated with β, and the ranking depends on certain measurable factors x and certain unobservable factors Є (Greene, 2000).

The marginal effects for the changes in the regressors are:

$$
\begin{aligned}
&\frac{\partial PROB[y=0]}{\partial x} = -\phi(\beta' x)\beta, \\
&\frac{\partial PROB[y=1]}{\partial x} = [\phi(-\beta' x0 - \phi(\mu - \beta' x)]\beta, \\
&\frac{\partial PROB[y=2]}{\partial x} = \phi(\mu - \beta' x)\beta.
\end{aligned}
\tag{3.5}
$$

(Greene, 2000).

<u>Questions Analyzed Using Ordered Probit</u>

Questions analyzed using the ordered probit model included:

- How often are your farm records updated? (Coded as Yearly = 0, Monthly = 1, Weekly = 2, and Daily = 3.)
- Please rate how useful your computer is to your farm operation. (Coded as Not at All Useful = 0, Limited Usefulness = 1, Moderate Usefulness = 2, and Very Useful = 3.)

The ordered probit model was used for these questions because it analyzes factors affecting the intensity of use or feeling in an ordered response question. An OLS regression model would not recognize the difference between a 3 and 4 ranking as different from the difference between a 2 and 3 ranking; however, the ordered probit would recognize that the values are a ranking even between categories that are not of equal size (Greene, 2000). On the other hand, the multinomial logit or probit model would fail to account for the ordinal value of the dependent variable (Greene, 2000).

In this specific case, the ordered probit model will explain what factors move a farmer from thinking their computer system is of limited usefulness to the farm up to thinking their computer system is moderately useful to the farm operation. In the same line of thinking, the ordered probit model will also analyze what compels a farmer to update records daily rather than weekly.

Cooper and Osborn (1998) used an ordered probit model to model what payment rates farmers would accept to re-enroll in conservation reserve program contracts. Clark and Oswald (1994) used the ordered probit model to determine if unemployment led to unhappiness. They used the ordered probit model because they used questions with ranked multiple responses. Carlson and Senauer used an ordered probit model to determine whether the WIC program had an impact on children's health (2003). The ordered probit model was appropriate because the children were evaluated by physicians who ranked their health status in different and ranked categories.

Ordinary Least Squares Regression Analysis

Ordinary least squares regression analysis was performed using STATA to determine what factors affected the number of hours spent each week updating the farmers' record keeping systems.

The regression model is: $Y_t = \alpha + \beta X_t + u_t$. (3.6)

where X_t and Y_t are the *t*th observations on the independent and dependent variables, α and β are the unknown parameters to be estimated, and u_t is the unobserved error term (Ramanathan, 1995).

Questions Analyzed Using Ordinary Least Squares (OLS) Regression

Question analyzed using the OLS regression model included:

- How many hours per week are spent updating/maintaining and analyzing farm records?

The OLS regression model was used to analyze these questions because the dependent variable was a non-censored, non-truncated, continuous variable.

Ott and Rendleman (2000) used a multiple regression model to determine the effect of rBST on dairy herd production and profit levels. In the ratite industry, Gillespie, Schupp, and Taylor (1997) used regression analysis to determine the producer characteristics that are likely to lead to higher technical efficiency. Mishra and Morehart (2001) used a regression model to determine which factors affected returns to labor and management skills on U.S. dairy farms.

Negative Binomial Regression Analysis

Negative binomial regression analysis was performed to determine the factors influencing the number of financial measures that farmers used to track their financial performance and the number of different financial statements they generated to measure their financial performance. The negative binomial regression model is:

$$\begin{aligned} f(y_i|x_i) &= \int_0^\infty \frac{e^{-\lambda_i u_i}(\lambda_i u_i)^{y_i}}{y_i!} \frac{\theta^\theta u_i^{\theta-1} e^{-\theta u_i}}{\Gamma(\theta)} du \\ &= \frac{\theta^\theta \lambda_i^{y_i}}{\Gamma(y_i+1)\Gamma(\theta)} \int e^{-(\lambda_i+\theta)u_i} u_i^{\theta+y_i-1} du_i \\ &= \frac{\theta^\theta \lambda_i^{y_i} \Gamma(\theta+y_i)}{\Gamma(y_i+1)\Gamma(\theta)(\lambda_i+\theta)^{\theta+y_i}} \\ &= \frac{\Gamma(\theta+y_i)}{\Gamma(y_i+1)\Gamma(\theta)} r_i^{y_i}(1-r_i)^\theta, \textit{ where } r_i = \frac{\lambda_i}{\lambda_i+\theta} \end{aligned} \tag{3.7}$$

where u_i defines the unconditional distribution and the conditional variance is given by $\lambda_i(1+(1/\theta)\lambda_i)$. Usually a gamma distribution (Γ) for $u_i=\exp(\epsilon_i)$ is chosen for mathematical convenience (Greene, 2000).

Questions Analyzed Using the Negative Binomial Regression Model

Questions analyzed using the negative binomial regression model included:

1. Do you track your operation's: liquidity (current assets/current liabilities), solvency (cash/current liabilities), profitability (net income/sales), repayment capacity (cash/total liabilities), and financial efficiency (net income/total assets)? (Recorded as the total number of listed measures used, 0-5).
2. Which financial statements do you use in your management activities: income statement, balance sheet, cash flow, or owner's equity? (Recorded as the total number of statements generated, 0-4).

The negative binomial regression model was used to analyze these questions because the responses were count data. They were not ordered responses. A specific statement or financial measure is assumed to have the same impact as any other specific statement or financial measure (Rahelizatovo and Gillespie, 2004). So the negative binomial regression model was able to analyze what factors affected the total number of ratios that farmers tracked or the total number of financial statements they used for financial management purposes. This model was chosen over the Poisson model because the negative binomial regression model can incorporate heteroskedastic errors (Greene, 2000).

Rahelizatovo and Gillespie (2004) used a negative binomial regression model to analyze influence on the adoption of different numbers of best management practices in the Louisiana dairy industry.

Double Hurdle Model Analysis

A double hurdle model, which consists of a probit model and a second stage truncated regression, was used to determine among those who were using DHIA to keep their production records, which factors influenced the hours per week spent analyzing the DHIA output. The double hurdle model is first a probit model to examine adoption, and second, a truncated regression to analyze intensity of adoption.

The probit model is:

$$PROB(Y=1)=\int_{-\infty}^{\beta' x}\phi(t)dt \\ =\phi(\beta' x) \qquad (3.10)$$

where the set of parameters β reflects the impact of changes in x on the probability of adoption (Greene, 2000).

The marginal effects for the probit model are: $\frac{\partial E[y/x]}{\partial x}=\phi(\beta' x)\beta,$ (3.11)

(Greene, 2000).

The truncated regression model is:

$$E[y_i|y_i>a]=\beta' x_i+\sigma\frac{\phi[(a-\beta' x_i)/\sigma]}{1-\Phi[(a-\beta' x_i)/\sigma]} \qquad (3.12)$$

where the set of parameters β reflects the impact of changes in x on the value of y_i and the conditional mean is a nonlinear function of a, σ, x, and β (Greene, 2000).

The marginal effects for the truncated regression model are:

$$\begin{aligned} &E[y_i|y_i.a]=\beta' x+\sigma\lambda(\alpha_i), \\ &where\ now\ \alpha_i=(a-\beta' x)/\sigma \\ &let\ \lambda_i=\lambda(\alpha_i)\ and\ \delta_i=\delta(\alpha_i)\ Then \\ &\frac{\partial E[y_i|y_i>a]}{\partial x_i}=\beta+\sigma\left(\frac{d\lambda_i}{d\alpha_i}\right)\frac{\partial\alpha_i}{\partial x_i} \\ &=\beta+\sigma(\lambda_i^2-\alpha_i\lambda_i)\left(\frac{-\beta}{\sigma}\right) \\ &=\beta(1-\lambda_i^2+\alpha_i\lambda_i) \\ &=\beta[1-\delta(\alpha_i)], \end{aligned} \qquad (3.13)$$

(Greene, 2000).

Question Analyzed Using the Double Hurdle Model

Question analyzed using the double hurdle model was:

1. Do you currently use DHIA to keep your production records? (Yes=1, No=0).
2. How many hours per week do you spend reviewing the DHIA output to improve your decision making process?

The double hurdle model was used to analyze these questions because the model allows for the analysis of adoption and also the analysis of the intensity of adoption. The probit model explains what factors influence the probability of adoption. The truncated regression analyzes the factors influencing the usage of the new technology.

Lin and Milon (1993) used a double hurdle model to examine how individuals' perceptions of shellfish attributes affected whether or not they consumed the shellfish and if so, how much they consumed. Cooper and Keim (1996) used a double hurdle model to predict farmer adoption of water quality programs based on different payment rates. Dong and Saha (1998) also used the double hurdle model, but geared toward technology adoption. They used the double hurdle model to analyze adoption and adoption intensity in the context of a divisible technology.

C. Explanatory Variables

The factors under consideration in this study include farm size (average number of milking-age cows), farmer's age and education, diversification, off-farm income, land tenure, prior positive adoption experiences, existence of a farm successor, whether or not the operator was the main record-keeper, and a measure of how many previous technologies the farmer has adopted. Specific variables and their coding follow.

AGE = The age of the main operator in years. Farmer's age is expected to reduce the probability of adoption (Rahelizatovo and Gillespie, 2004; Barham et al., 2004; Zepeda, 1994).

Older farmers are generally less likely to adopt technologies if they cannot realize the full stream of benefits prior to retirement. Many farmers have suggested to interviewers that they considered themselves to be "too old to learn something new," and others have said that they "did not trust computers." Age was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

DEGR = A dummy variable taking the value of 1 if the dairy operator held a four year college degree and the value 0 if the operator did not have a college degree. (This includes bachelors, masters, and/or doctorate degrees). Higher levels of farmer education are expected to increase the probability of technology adoption (Barrett et al., 2004; Barham et al., 2004; Zepeda, 1994; Shields, Rauniyar, and Goode, 1993). Education is likely to increase the ability of the operator to learn how to use a new, technically complex technology. DEGR was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression

- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

AVGMC = The average number of milking age cows during the period from January 2004 to December 2005, calculated as inventory at January 1, 2004 + inventory at January 1, 2005 + inventory at December 31, 2005 all divided by 3. Farm size is expected to have a positive influence on the probability of technology adoption, especially for the computerized record-keeping and internet technologies, since larger farms have more units of production to spread the fixed costs of adoption over. Rahm and Huffman (2001); Saha, Love, and Schwart (2001); Barrett et al. (2004); and Barham et al. (2004) analyzed the effects of farm size on technology adoption. AVGMC was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

DIVDUM = A dummy variable taking the value of one if the farm included a farm enterprise other than the dairy. DIVDUM took a 0 value if there was no enterprise other than the dairy. Operational diversification is expected to reduce the probability of adoption of dairy-specific technologies, since farmers must justify a technology's usefulness to the entire operation. DIVDUM was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

FAMSUC = A dummy variable taking the value 1 if the operator was planning to pass the dairy operation down to a family successor. The availability of a farm successor may have a positive influence on computer and internet adoption since the older operators are likely to be involved with a (normally) younger successor that may know more about computer and internet technologies (Mishra and Williams, 2006). Having a family successor may also effectively extend the planning horizon of the operator, providing an incentive to invest in technologies even in cases in which he may not be able to personally realize the flow of benefits from adopting a new technology. FAMSUC was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression

- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

OFFFINC = The percentage of total gross income for the operator's family that was not earned on the farm. Higher levels of off-farm income are expected to reduce production efficiency because of time constraints (Goodwin and Mishra, 2004). However, higher off farm income is expected to increase the probability of computer and internet technologies, according to Doye (2004). OFFFINC was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

OWN = The percentage of total acres operated that the operator owned. For the adoption of best management practices, higher levels of farm ownership typically increase the probability of adoption (Rahelizatovo and Gillespie, 2004; Zepeda, 1994; Rahm and Huffman, 2001). However, in this study the expected relationship is unknown because the technologies under examination are not tied to a specific tract of land. Thus, the variable is included for explanatory purposes. OWN was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit

- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer’s Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression
- Intensity of DHIA Adoption-Double Hurdle

TECH = A count variable representing the number of other technologies adopted to measure the farmer’s propensity to adopt new technologies. The technologies included in this variable were total mixed ration feeding, silage feeding, balage feeding, artificial insemination, Global Positioning Systems (GPS), rotational grazing (the breaking up and utilizing pastures in sections), computer adoption, and the use of growth hormones. If a farmer has had a positive experience with the adoption of other technologies or management practices, it can be expected that he or she will be more willing to try other new technologies such as the technologies under analysis in this study (Saha, Love, and Schwart, 2001; Klotz, Saha, and Butler, 1995). TECH was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer’s Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression

- Intensity of DHIA Adoption-Double Hurdle

STMTS = A count variable representing the number of financial statements that were generated for the operator's analysis including the balance sheet, income statement, cash flow statement, and the statement of owner's equity. A higher number of financial statements is expected to lead to higher probability of computerized record-keeping systems adoption, since creation of financial statements is much simpler with a computer versus creating statements by hand. STMTS was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression

IROPER = A dummy variable taking the value of 1 if the farm's financial records are kept internally (not by an accounting professional) by the dairy operator. If the operator himself or herself is responsible for maintaining the financial and production records, it is expected that he or she will have less time to devote to record-keeping. When records are kept by the operator, they will likely be updated less often and in a lesser degree of detail. IROPER was included in the following models:

- Computerized Record-keeping Systems Adoption-Logit
- Internet Adoption-Logit
- Frequency of Updating Records-Ordered Probit
- Farmer's Perceived Usefulness of Their Computer System-Ordered Probit
- Hours per Week Spent Updating Record-keeping Systems-OLS Regression
- Production Efficiency (Lbs of Milk/Cow/Year)-OLS Regression
- Number of Financial Measures Tracked-Negative Binomial Regression
- Number of Financial Statements Generated-Negative Binomial Regression

- Intensity of DHIA Adoption-Double Hurdle

D. Statistical Testing

The main statistical concern in this study was the significance of the explanatory variables in each model. A significance level of ten percent ($\alpha = 0.10$) was used to test each variable for a statistical difference from zero.

Multicollinearity may cause problems because it can prevent the actual relationships between the data from being apparent and some parameters may have significance problems (Hill, Griffiths and Judge, 2001). After constructing a collinearity matrix in STATA using all the explanatory variables in each empirical model, pairs of variables were checked to determine whether there were collinear relationships. Any relationship near or above 0.8 for the correlation coefficients was considered to be collinear, as suggested by Hill, Griffiths and Judge (2001).

Variance inflation factors (VIF) were also used to detect collinearity. The VIFs are the diagonal elements in the inverse of the correlation matrix. "The VIFs are given by $(1-R_i^2)^{-1}$ where R_i^2 is the R^2 from regressing the *i*th independent variable on all other variables" (Kennedy, 1998, p. 190). High values for the VIF indicate an R^2 of near one and, therefore, suggests collinearity. Typically, a VIF > 10 indicates harmful collinearity (Kennedy, 1998).

Heteroskedasticity is often a problem with cross-sectional data because with larger firms, it is more difficult to explain the variation in the independent variable with the variation in the explanatory variables. Heteroskedasticity causes the probability density function to be more "spread out" than if the errors were homoskedastic (Hill, Griffiths and Judge, 2001). With heteroskedastic errors, the least squares estimator remains linear and unbiased, but it is no longer the best linear unbiased estimator. The standard errors are overestimated so that the hypothesis test and confidence intervals that depend on the standard errors can be misleading (Hill, Griffiths and Judge, 2001).

To test for heteroskedasticity, the residuals were plotted against each of the continuous explanatory variables; non-random relationships were searched for, as suggested by Hill, Griffiths and Judge (2001). A more formal heteroskedasticity test was also used: the Breusch-Pagan test in STATA. The null hypothesis for this test is that the variance is constant, and the alternative is that the variance is non-constant, or heteroskedastic.

Endogeneity is defined as "any situation where an explanatory variable is correlated with the disturbance," (Wooldridge, 2002). Endogeneity arises from: omitted variables, measurement errors, and simultaneity which occurs when "an explanatory variable is determined simultaneously along with y", (Wooldridge, 2002). To test for simultaneous endogeneity, the Hausman endogeneity test was used. The first step was to estimate a negative binomial regression model to predict the values of STMTS, TECH, COMPREC (computerized record-keeping systems adoption dummy variable), and CRHRS (the hours per week spent updating computerized record-keeping systems). Then the residual values from the instrumental variable were included in the main regressions, with t-statistics on the residuals checked for significance. Significant t-statistics would signify endogeneity.

CHAPTER 4: RESULTS AND DISCUSSION

A. Response Rate

Of the 310 farmers contacted, 50 agreed to the interview, 68 would not agree to be interviewed, 33 were out of the dairy business, 14 did not have a listed phone number, 27 had incorrect or disconnected numbers, and 101 farmers never answered the phone upon being called repeatedly. This gives an adjusted response rate of 42.37% (50/118 = (yes / yes + no)).

B. General Statistics

The average farmer had 30 years of experience in the dairy industry and the average farm size was 326 acres with 111 milking age cows. The average production per cow per year was 15,680 lbs. Since this is higher than the state average, more efficient producers were more likely to agree to the survey.

Also, in the 2002 U.S. Census of Agriculture most Louisiana dairy farmers were between 45 and 64 years of age; this study found the average to be 53 years of age. However, the data used in this study did come from larger than average farms as is shown in table 4.1. In the data from the census, the average farm size was between 100 and 139 acres and the average number of milking age cows was between 50 and 99 cows (USDA, Census of Agriculture, 2002). However, the data gathered for this study show the average farm size to be 326 acres and 111 milking age cows. This further suggests that larger and more efficient farmers were more likely to agree to participate in the survey. Another explanation that must be considered is the consolidation trend discussed in Chapter 1. Some of the smaller farms may have sold out to larger farms in the four years between the dates of collection of the data for the 2002 Census of Agriculture and the data used in this study.

Forty percent of the farmers (20 out of 50) had attended college classes or had a college degree (Table 4.1). Thirteen farmers (26%) planned to pass the dairy on to their children. The other 37 farmers planned to sell the dairy or had no children to take over upon their retirement.

Table 4.1. Summary Statistics for Explanatory Variables

	Units	Mean	Std. Dev	Min	Max	Census
AGE	Years	53.00	11.18	27.00	74.00	45-64
DEGR	0-1	0.30	0.46	0.00	1.00	
AVGMC	No.	110.65	55.23	16.67	240.00	50-99
DIVDUM	0-1	0.46	0.49	0.00	1.00	
FAMSUC	0-1	0.26	0.44	0.00	1.00	
OFFFINC	%	17.71	28.55	0.00	100.00	
OWN	%	0.71	0.32	0.00	1.00	
TECH	No.	2.92	1.45	0.00	6.00	
TMR	0-1	8.00	0.37	0.00	1.00	
DHIAC	0-1	18.00	0.48	0.00	1.00	
COMPREC	0-1	15.00	0.48	0.00	1.00	
STMTS	No.	1.78	1.41	0.00	4.00	
IROPER	0-1	21.00	0.50	0.00	1.00	

C. Technology Adoption/Usage

Computers were used by 78% of the farmers surveyed (39 out of 50) and fifteen of those used the computer to keep their financial records (30%) (Table 4.3). On average, these farmers believed their computers were of limited usefulness to their farm operation. Of the 50 farmers, eighteen (36%) were currently using DHIA to keep their production records. Overall, most farmers updated their financial records weekly or monthly. Only two farmers filed their own tax returns without the aid of a tax professional.

There are almost equal numbers of farms using DHIA, computerized record-keeping systems, or both. DHIA and computerized record-keeping systems are not substitutes for one another, but instead they can be complementary technologies. Of most concern is the 21 farmers who do not use DHIA or computerized record-keeping systems to closely manage their production or financial efficiency.

Table 4.2. Record-Keeping Systems Usage

Type of Record-Keeping System Used	Number
Used both DHIA and computerized record-keeping systems	8
Used DHIA only	9
Used only computerized record-keeping systems	7
Blank	5
Used neither DHIA or computerized record-keeping systems	21
Total	50

Thirty farmers (60%) generated cash flow statements, while only 21 (42%) generated balance sheets. Fewer generated income and owner's equity statements, 19 (38%) and 10 (20%) respectively. Thirty-four farmers (68%) tracked their liquidity closely, while 23 (46%) tracked solvency, 21 (42%) tracked profitability, 20 (40%) tracked repayment capacity, and 14 (28%) tracked financial efficiency.

Four farmers (8%) used growth hormones (rBST), while 25 (50%) used artificial insemination. Eight farmers (18%) fed total mixed rations, eleven (22%) fed silage, and eleven (22%) fed balage.

Table 4.3. Technology Adoption Summary

Technology	Number of Adopters	%
Growth Hormones	4	8%
Artificial Insemination	25	50%
Total Mixed Ration	8	16%
Silage	11	22%
Balage or Haylage	11	22%
Computerized Records	15	30%
DHIA users	18	36%
Internet users	25	50%
GPS or GIS Technology	5	10%
Rotational Grazing	43	86%

D. Statistical Tests

Table 4.4 shows collinearity diagnostics using correlation coefficients. All of the relationships were well within the 0.8 rule of thumb.

Table 4.4. Collinearity Matrix

Explanatory Variables Collinearity Matrix

	AGE	DEGR	IROPER	AVGMC	DIVDUM	FAMSUC	OFFFINC	OWN	TECH	STMTS
AGE	1.0000									
DEGR	0.0185	1.0000								
IROPER	0.0197	0.0449	1.0000							
AVGMC	-0.0542	-0.0305	-0.0071	1.0000						
DIVDUM	0.0364	0.1473	-0.0256	0.1591	1.0000					
FAMSUC	0.2422	0.1762	-0.0138	0.0945	0.0991	1.0000				
OFFFINC	-0.0995	0.3064	0.1576	-0.4811	-0.0488	-0.0446	1.0000			
OWN	0.0714	-0.0413	-0.0478	0.2599	0.2078	0.0004	-0.1301	1.0000		
TECH	-0.2226	0.2060	0.0637	0.1298	0.4936	0.1109	-0.0675	-0.0390	1.0000	
STMTS	-0.1397	0.0726	-0.2977	0.1587	0.1495	0.1275	-0.0698	0.0799	0.2162	1.0000

The VIF test for multicollinearity gave a mean VIF of 1.35 and none of the VIF values were above 2. Since a VIF greater than 10 indicates harmful collinearity (Kennedy, 1998), this test showed that multicollinearity was not a concern for this data.

There also were no endogenous relationships between the explanatory variables when the Hausman test was used. The t-statistics all showed no significance for the residual values from the prediction model, when placed in the original model.

However, the data were heteroskedastic. The plots of the residuals showed a clear pattern of the residuals increasing as the continuous explanatory variables increased. The Breusch-Pagan test in STATA gave a value of 8.98 and a p-value of 0.0027, so at the ten percent level of significance, the null hypothesis of constant variance was rejected showing heteroskedasticity. The Robust command in STATA was used to correct for heteroskedasticity in the standard errors in the regression models.

E. Analysis Results

<u>Adoption Logits</u>

The adoption of computerized record-keeping systems and internet usage were analyzed using logit models. Thirty percent of the farmers in this study had adopted computerized record-keeping systems. The only independent variable found to significantly affect the probability of a farmer using computerized record-keeping systems was the number of statements created to assist the decision maker (Table 4.5). A test for endogeneity was conducted to determine whether the number of statements created was endogenous. The test was conducted as shown in Wooldridge (2002) with the independent variables AGE, DEGR, AVGMC, DIVDUM, FAMSUC, OFFFINC, OWN, TECH, STMTS, IROPER. The number of statements generated was not found to be endogenous in this model. Creating one more statement for use in the financial analysis increased the probability of adoption by 0.1687. This follows conventional logic, since computers are likely to reduce the amount of time needed to create a financial statement.

The percent correctly predicted is calculated by taking the total number of predicted values that were correct when compared to the actual values and dividing that by the total number of predictions (same as the observations).

Table 4.5. Adoption of Computerized Record Keeping Systems

Adoption of Computerized Record Keeping Systems

	Coefficient	Standard Error	P-Value	Marginal Effect	Standard Error	P-Value
age	0.051061	0.041210	0.215	0.010483	0.008360	0.210
degr	-0.016789	0.886351	0.985	-0.003442	0.181530	0.985
avgmc	0.005817	0.008297	0.483	0.001194	0.001720	0.487
divdum	-0.721621	0.991432	0.467	-0.142943	0.186060	0.442
famsuc	-1.362965	1.077615	0.206	-0.234928	0.148900	0.115
offfinc	0.007898	0.015038	0.599	0.001622	0.003100	0.601
own	0.548727	1.313504	0.676	0.112658	0.267990	0.674
tech	0.370791	0.343814	0.281	0.076126	0.071290	0.286
stmts	0.821757	0.315736	0.009	0.168713	0.062200	0.007
iroper	0.470169	0.805377	0.559	0.096951	0.166230	0.560
constant	-6.913780	3.134664	0.027	Percent Correctly Predicted		77.78 %
Pseudo R2	0.2225			Number of Observations		45

Experience with the internet was affected by four factors, including farm size, family successor, off-farm income, and previous technology adoption (Table 4.6). Fifty-two percent of the farmers in this study had experience with the internet. Larger farms were more likely to have experience with the internet. An increase in the average number of milking cows by one cow increased the probability of internet experience by 0.0048. Contrary to expected results, when a farmer had a family successor, he or she was less likely to adopt internet technologies. Possibly, when a farmer had a son or daughter he or she could trust to do business activities for the dairy over the internet, the farmer felt he or she did not have to learn about computers and internet because the successor could do that for them.

As expected, higher levels of off-farm income led to a greater probability of internet experience. This likely occurs partially because more people are exposed to internet technologies in their off-farm jobs. In addition, the off-farm job provides additional disposable income from which internet services may be paid for. Farmers who were technology adopters were more likely to have experience with internet technologies. The probability of internet experience increased by 0.1570 for every additional technology the farmer had already adopted.

Table 4.6. Experience with Internet Technologies

Experience with the Internet

	Coefficient	Standard Error	P-Value	Marginal Effect	Standard Error	P-Value
age	0.050728	0.037221	0.173	0.012679	0.00929	0.172
degr	1.125230	0.939837	0.231	0.270477	0.20944	0.197
avgmc	0.019161	0.000948	0.043	0.004789	0.00237	0.043
divdum	-1.057980	0.984343	0.282	-0.258131	0.22849	0.259
famsuc	-1.992231	1.072605	0.063	-0.440137	0.18828	0.019
offfinc	0.044661	0.019358	0.021	0.111631	0.00483	0.021
own	-0.699425	1.344010	0.603	-0.174822	0.33592	0.603
tech	0.628182	0.377076	0.096	0.157015	0.09425	0.096
iroper	-0.220915	0.764014	0.772	-0.055167	0.19040	0.772
constant	-6.307549	2.807133	0.025			
Pseudo R2	0.2827			Percent Correctly Predicted		64.44 %
				Number of Observations		45

Ordered Probit Record-Keeping System Frequency of Updating

An ordered probit model was used to analyze factors influencing how often the farm records were updated (Table 4.7). Updating once per year was used as the base group. Groups one, two, and three were monthly, weekly, and daily updating, respectively. Six farmers updated records yearly, sixteen updated monthly, sixteen updated weekly, six updated daily, and six farmers did not answer the question. In the overall ordered probit model, having a college degree and having a diversified operation both reduced the frequency at which records were updated.

No factors were found to significantly reduce or increase the probability of a farmer updating their financial records only once per year. The factors that increased the probability of a farmer updating financial records monthly included having a college degree and the farm consisting of an operation other than the dairy. A farmer having a college degree was 0.1256 more likely to update records on a monthly basis. If the farm contained enterprises other than the dairy itself, then the farmer was 0.1510 more likely to update records on a monthly basis.

Table 4.7. Frequency of Updating Records, Ordered Probit

Frequency of Updating Records

	Overall Model			**Yearly**			**Monthly**		
Variable	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value
age	-0.012414	0.0165	0.451	0.002082	0.0028	0.462	0.002850	0.0039	0.464
degree	-0.676343	0.4004	0.091	0.133402	0.0939	0.156	0.125606	0.0735	0.088
avgmc	0.002671	0.0037	0.474	-0.000448	0.0006	0.483	-0.000613	0.0009	0.486
divdum	-0.757394	0.4388	0.084	0.140525	0.0956	0.141	0.151000	0.0886	0.088
famsuc	0.442608	0.4057	0.275	-0.064323	0.0544	0.237	-0.110788	0.1114	0.320
offfinc	-0.005639	0.0071	0.425	0.000946	0.0012	0.435	0.001295	0.0017	0.440
own	-0.600979	0.5507	0.275	0.100810	0.0955	0.291	0.137960	0.1349	0.306
tech	0.176462	0.1538	0.251	-0.029600	0.0266	0.266	-0.040508	0.0380	0.287
iroper	0.242384	0.3389	0.474	-0.040437	0.0573	0.481	-0.055675	0.0797	0.485
$\mu1$	-1.967515	1.2464							
$\mu2$	-0.560385	1.2265							
$\mu3$	0.663625	1.2292							

	Weekly			**Daily**				
							Pseudo R2	0.1140
	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value	Number of Observations	44
age	-0.002845	0.0039	0.463	-0.002087	0.0028	0.460		
degree	-0.161125	0.1032	0.118	-0.097883	0.0575	0.088		
avgmc	0.000612	0.0009	0.485	0.000449	0.0006	0.481		
divdum	-0.173070	0.1080	0.109	-0.118455	0.0709	0.095		
famsuc	0.089281	0.0755	0.237	0.085830	0.0910	0.345		
offfinc	-0.001293	0.0017	0.438	-0.000948	0.0012	0.434		
own	-0.137754	0.1323	0.298	-0.101016	0.0969	0.297		
tech	0.040448	0.0374	0.279	0.029661	0.0269	0.270		
iroper	0.055044	0.0779	0.480	0.041108	0.0588	0.484		

No factors were found to significantly increase or decrease the probability of a farmer updating records on a weekly basis. However, having a degree and a diversified operation both reduced the probability of a farmer updating their financial records on a daily basis. When the farmer held a college degree, he was 0.0979 less likely to update records daily. When the farm contained an enterprise other than the dairy, the farmer was 0.1185 less likely to update financial records on a daily basis.

For both the frequency of updating records and the computer perceived usefulness ordered probit models, the $\mu 1$, $\mu 2$, and $\mu 3$ values represent the threshold values between the response categories. Therefore, the reported $\mu 1$ is the constant term for the model.

<u>Ordered Probit for Computer Perceived Usefulness</u>

An ordered probit model was used to explain the factors impacting the perceived usefulness of a computer (Table 4.8). Six farmers perceived the computer to be not at all useful, eleven perceived the computer to be of limited usefulness, seven perceived the computer to be of moderate usefulness, fourteen perceived the computer to be very useful, and twelve farmers either did not have a computer or did not answer the question. In the overall model, age, diversification, the presence of a family successor, and previous technology adoption affected how useful a farmer believed his computer system to be.

The category of not at all useful mainly applies to those farm households that had a computer but did not use it for any farm business purposes. These were likely used mainly for children's homework assignments, recreation, and other similar activities. Farmers who had previously adopted other technologies were 0.0767 less likely to rank their computer as not at all useful. Diversified farmers were 0.2243 more likely to answer that their computer system was not at all useful to their farm business. Both of these relationships were expected based on previous adoption studies' findings. However, what was not expected was the finding that younger farmers were 0.0094 more likely to rank their computers as not at all useful. Most adoption theories suggest the opposite, especially with computer technologies. This could be the case, however, because younger farmers have not yet observed the long-run benefits of good record-keeping.

Table 4.8. Computer Usefulness

Computer Usefulness

	Overall Model			**Not at all useful**			**Limited usefulness**		
Variable	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value
age	0.049538	0.0214	0.021	-0.009352	0.0048	0.050	-0.010057	0.0060	0.095
degree	0.539153	0.4735	0.255	-0.095863	0.0854	0.262	-0.110565	0.1040	0.288
avgmc	0.004348	0.0047	0.356	-0.000802	0.0009	0.366	-0.000883	0.0010	0.391
divdum	-1.071023	0.5075	0.035	0.224261	0.1253	0.073	0.181061	0.0995	0.069
famsuc	-0.978252	0.5631	0.082	0.245708	0.1771	0.165	0.128555	0.0752	0.087
offfinc	0.003867	0.0077	0.617	-0.000730	0.0015	0.618	-0.000785	0.0016	0.626
own	0.916226	0.6458	0.156	-0.172976	0.1315	0.188	-0.186001	0.1505	0.217
tech	0.406277	0.1982	0.040	-0.076702	0.0422	0.069	-0.082478	0.0532	0.121
iroper	0.467691	0.4516	0.300	-0.089400	0.0917	0.330	-0.092467	0.0915	0.312
stmts	0.191681	0.1578	0.224	-0.036188	0.0318	0.255	-0.038913	0.0353	0.270
µ1	3.937362	1.5909							
µ2	4.97053	1.6560							
µ3	5.484137	1.6687						Pseudo R2	0.1530
								Number of Observations	35

	Moderately Useful			**Very useful**		
	Coefficient	Std. Error	P-Value	Coefficient	Std. Error	P-Value
age	0.000654	0.0021	0.759	0.018755	0.0082	0.022
degree	0.001321	0.0223	0.953	0.205108	0.1786	0.251
avgmc	0.000057	0.0002	0.767	0.001646	0.0018	0.358
divdum	-0.026192	0.0439	0.550	-0.379131	0.1607	0.018
famsuc	-0.054538	0.0611	0.372	-0.319725	0.1519	0.035
offfinc	0.000051	0.0002	0.794	0.001464	0.0029	0.617
own	0.012093	0.0399	0.762	0.346884	0.2453	0.157
tech	0.005362	0.0175	0.760	0.153817	0.0756	0.042
iroper	0.006609	0.0198	0.739	0.175258	0.1678	0.296
stmts	0.002530	0.0084	0.763	0.072571	0.0601	0.227

The next computer usefulness category was limited usefulness. Farmer age, family successor, and farm diversification all affected the probability of a farmer classifying their computer system as limited in usefulness. Older farmers were 0.0101 for every year of age less likely to rate their computer systems as limited in usefulness. Those farms with more operations than just a dairy were 0.1811 more likely to rate their computer as of only limited usefulness.

Also, those farmers who had a family successor to take over the dairy operation were 0.1286 more likely to rank their computer as limited in usefulness.

No factors were found to significantly increase or decrease the probability of a farmer ranking his computer as moderately useful. However, four factors contributed to a farmer ranking their computer as very useful. These factors included age, diversification, family successors, and prior technology adoption. Older farmers were 0.0188 for each year of age more likely to rate their computer systems as very useful. Farms with more enterprises than just the dairy were 0.3791 less likely to rate their computer systems as very useful to the farm business. Having a family successor for the dairy operation also reduced the probability by 0.3197 of a farmer rating their computer system as very useful. Conversely, each prior technology adoption increased the probability of providing this response by 0.1538.

<u>OLS Regression Explaining Computer Record-Keeping System Hours per Week</u>

An ordinary least squares regression was used to analyze the factors affecting the amount of time each week that is spent updating financial records (Table 4.9). The average farmer spent 2 hours per week updating their computerized records. The only factor found to affect the hours spent updating records was the amount of off-farm income. For every one percent increase in total income brought in from off-farm sources, farmers spent 0.0148 fewer hours (or 0.9 minutes) per week updating their financial records. Even though this value is not large, it is consistent with previous research and economic theory because when an individual is working off the farm, he has less time to devote to farm tasks. Also, people working off the farm may have received training in how to keep records, and therefore they may be able to update records much faster.

<u>Negative Binomial Regression Explaining Tracking of Financial Measures</u>

A negative binomial regression was used to explain the number of financial measures that a farm business calculated and tracked for their financial analysis and decision making process (Table 4.10). Thirty-four farmers tracked their liquidity closely, while 23 tracked solvency, 21 tracked profitability, 20 tracked repayment capacity, and 14 tracked financial efficiency.

Table 4.9. Computerized Record-Keeping System Hours per Week

Computerized Record-Keeping hrs/week			
Variable	Coefficient	Standard Error*	P-Value
age	0.030599	0.0187	0.113
degree	-0.587552	0.4910	0.241
avgmc	-0.001414	0.0054	0.795
divdum	-0.372295	0.7801	0.637
famsuc	0.550797	0.7311	0.458
offfinc	-0.014788	0.0082	0.082
own	-0.877467	0.5437	0.118
tech	0.135126	0.2022	0.509
stmts	-0.245012	0.2116	0.257
iroper	-0.803975	0.5475	0.153
constant	1.994474	1.1977	0.107
* Robust Standard Errors			
R-squared			0.3106
Number of Observations			39

Table 4.10. Number of Financial Measures Tracked

Number of Financial Measures Tracked						
Variable	Coefficient	Standard. Error	P-Value	Marginal Effect	Standard Error	P-Value
age	0.006293	0.0103	0.542	0.014771	0.0242	0.541
degree	0.115479	0.2283	0.613	0.277184	0.5603	0.621
avgmc	0.002157	0.0023	0.338	0.005063	0.0053	0.337
divdum	0.163733	0.2458	0.505	0.391097	0.5974	0.513
famsuc	0.470095	0.2231	0.035	1.255749	0.6701	0.061
offfinc	0.006791	0.0042	0.105	0.015939	0.0097	0.102
own	0.042285	0.3350	0.900	0.099252	0.7862	0.900
tech	-0.002106	0.0909	0.982	-0.004944	0.2135	0.982
iroper	0.114819	0.2091	0.583	0.270687	0.4952	0.585
constant	-0.133950	0.7853	0.865			
lnalpha	-3.137188	2.8935				
alpha	0.043405	0.1256				
Pseudo R2	0.0551					

The only variable that significantly affected the number of financial measures was the existence of a family successor. A farmer having a successor was likely to track 1.2557 more financial measures than a farmer with no successor. Once again, this result is consistent with economic theory because the farmers that keep a closer watch on their financial position are the farmers that want to preserve their farm to be passed down to their children.

Negative Binomial Regression Explaining Generation of Financial Statements

A negative binomial regression was used to explain the number of financial statements that a farm business generated and analyzed (Table 4.11). Thirty farmers generated cash flow statements, while only 21 generated balance sheets. Fewer generated income and owner's equity statements, 19 and 10 respectively. Only one factor influenced the number of statements generated, and that was whether the financial records were updated by the farm operator himself. If the records were updated by the operator, then on average he created 0.8612 fewer statements than if someone besides the operator updated the farm's financial records. This result is as expected because the operator would not have as much time to devote to creating statements as would someone else involved in the farm business.

Table 4.11. Number of Statements Generated

Number of Statements Generated

Variable	Coefficient	Standard Error	P-Value	Marginal Effect	Standard Error	P-Value
age	-0.008567	0.0112	0.446	-0.014328	0.0187	0.445
degree	0.010238	0.2595	0.969	0.017156	0.4657	0.969
avgmc	0.001140	0.0024	0.636	0.001907	0.0040	0.636
divdum	0.072911	0.2746	0.791	0.122860	0.4660	0.792
famsuc	0.231785	0.2638	0.380	0.412228	0.4967	0.407
offfinc	0.001165	0.0049	0.813	0.001948	0.0082	0.813
own	0.142228	0.3832	0.711	0.237870	0.6402	0.710
tech	0.107117	0.1089	0.325	0.179149	0.1808	0.322
iroper	-0.518074	0.2445	0.034	-0.861181	0.3958	0.030
constant	0.552755	0.8398	0.510			
lnalpha	-15.36706	1041.999				
alpha	0.000000	.0002				
Pseudo R2	0.0599					

Double Hurdle Explaining DHIA Adoption and Intensity

A double hurdle model was used to analyze the factors affecting DHIA adoption and intensity of use (Table 4.12). The first hurdle was a probit model used to analyze what factors affected DHIA adoption, and the second hurdle was a truncated regression used to analyze what factors impacted the intensity of DHIA records usage.

In the probit model, herd size and prior technology adoption were found to affect the adoption rate of DHIA. Eighteen farmers adopted DHIA. Larger farmers had a higher probability of adopting DHIA (probability of adoption increased by 0.0036 per additional cow). Also, farms that had already successfully adopted technologies were 0.3028 more likely to adopt DHIA for each individual technology they had already adopted. Both of these results are consistent with economic theory.

The average DHIA user spent 1.22 hours per week reviewing DHIA output. In the truncated regression, off farm income, family successors, prior technology adoption, farm operation diversification, and whether or not the operator himself updated the financial records all had significant effects on how many hours per week the operator spent reviewing the DHIA output. Higher levels of off-farm income reduced the time spent reviewing DHIA output. Having a family successor increased the hours spent per week reviewing the output by 1.7036 hours per week. Each new technology a farmer adopted reduced the hours spent reviewing the output by 0.4740. Diversification in the farming operations increased the time spent assessing the farm's performance via DHIA records. When the operator himself updated the financial records, then he spent 0.7228 more hours per week studying the DHIA output (1.7036, 0.4740, and 0.7228 are the marginal effects for the significant variables).

Table 4.12. Adoption and Intensity of DHIA Use-Double Hurdle Model

Adoption and Intensity of DHIA Use

		Probit				
Variable	Coefficient	Standard Error	P-Value	Marginal Effect	Standard Error	P-Value
age	0.017727	0.0275	0.519	0.005724	0.0091	0.531
degree	-0.252765	0.6716	0.707	-0.078769	0.1999	0.694
avgmc	0.011170	0.0065	0.086	0.003607	0.0021	0.088
own	-0.950249	1.0008	0.342	-0.306829	0.3146	0.329
offfinc	-0.001924	0.0110	0.861	-0.000621	0.0035	0.860
famsuc	-0.051951	0.7098	0.942	-0.0166368	0.2260	0.941
tech	0.937781	0.3232	0.004	0.302803	0.1031	0.003
divdum	0.614931	0.5720	0.282	0.204162	0.1955	0.296
constant	-5.010449	2.1685	0.021		Pseudo R2	0.5240
	Truncated Regression				Percent Correctly Predicted	88.00%
Variable	Coefficient	Standard Error	P-Value			
age	0.005824	0.0179	0.745			
degree	-0.231465	0.3155	0.463			
avgmc	0.003618	0.0025	0.151			
own	0.035778	0.3777	0.952			
offfinc	-0.020243	0.0091	0.027			
famsuc	1.703634	0.4774	0.000			
tech	-0.473994	0.1692	0.005			
divdum	1.011180	0.5293	0.056			
iroper	0.722831	0.3679	0.049			
constant	1.105159	1.1201	0.324			
sigma	0.440879	0.0878	0.000			

CHAPTER 5: SUMMARY AND CONCLUSIONS

A. Summary

This study reviewed the adoption of record-keeping technologies to give farmers and extension personnel the information needed to support farmers' adoption decisions. Record-keeping technologies were specifically studied because of the impact the adoption of these systems can have on production per cow and financial management activities.

The objectives of this study were to determine: (1) what technologies were being adopted by dairy farmers, (2) which types of farmers were adopting technologies, (3) how useful computer technologies were perceived to be, (4) which farmers were more likely to perceive computer technologies as being useful, (5) to what detail farmers were tracking their production and financial information, and (6) the intensity of use of new technologies.

Surveys of fifty Louisiana dairy farmers were completed to achieve these objectives. The data were compiled into a spreadsheet and then analyzed using logit, ordered probit, negative binomial regression, OLS regression, and double hurdle models to determine the factors that affected adoption, the frequency of updating records, perceived computer usefulness, the number of financial measures tracked, the number of financial statements generated, the hours spent reviewing DHIA output, the hours spent updating computerized record-keeping systems, and the adoption and intensity of use of DHIA.

B. Results

In this study, age was found to decrease the probability that a farmer would believe their computer was not at all useful and also of limited usefulness, while increasing the probability that a farmer would believe the computer was very useful to the farm business. Older farmers were more likely to perceive the computer as more useful. This was not expected. This does suggest that older farmers may remember that it was more challenging to manage a dairy without computer technology and younger farmers are so accustomed to computers that they take computers' usefulness to the farm for granted.

A college education at the bachelor's or master's level was found to reduce the probability of a farmer updating records on a daily basis and increase the probability of updating records on a monthly basis. Thus, more educated farmers updated their records monthly. Originally, more educated farmers were expected to update records more frequently (daily or weekly) so that they would have very current information with which to make more accurate decisions. The results from this study suggest that more educated farmers update their records monthly possibly because they can update records faster and therefore they can update records less often.

Farm size was found to increase the adoption of the internet and DHIA, which was expected and is consistent with previous adoption studies.

Having an enterprise other than the dairy affected several things, including: increasing the probability of a farmer updating records on a monthly basis; decreasing the probability of updating records on a daily basis; increasing the probability of a farmer perceiving the computer as not at all and of limited usefulness to the farm business; decreasing the probability of a farmer perceiving their computer as very useful to the farm business; and it also increased the time spent per week reviewing DHIA output. Thus, more diversified producers tended to review records at a moderate level of frequency and find computers less useful.

Having a family successor to take over the dairy upon the operator's retirement affected many things, including: decreasing experience with the internet; increasing the probability of a farmer perceiving the computer as of limited usefulness; decreasing the probability of a farmer perceiving the computer as very useful; increasing the hours spent per week reviewing DHIA output; increasing the number of financial measures tracked; increasing the intensity of use of

DHIA after it has been adopted; and increasing the probability of adopting computerized record-keeping systems. Thus, having a family successor tends to increase the adoption of record-keeping technologies and therefore indicates closer financial management, but also reduces the perceived usefulness of the computer probably because the successor and not the operator is the one actually using the computer to perform tasks for the farm business.

Higher levels of off-farm income increased the probability of experience with the internet, but decreased the hours spent per week updating computerized record-keeping systems and the hours spent reviewing DHIA output. Thus, off-farm employment may expose farmers to computer technology, even if they effectively have less time to fully utilize it for farming purposes.

If the operator himself kept the records for the farm, then fewer financial statements were generated and less time was spent updating computerized record-keeping systems. These farmers, however, devoted more time to reviewing DHIA output. So when the farmer has more limited time, they spend the majority of their time trying to maximize production instead of focusing on financial management activities.

When the farmer was a technology adopter he was more likely to have experience with the internet and to have adopted DHIA, but spend less time reviewing DHIA output. Also, technology adopters were more likely to view the computer as very useful and less likely to view the computer as not at all useful. So technology adopters may be more open to accepting and appreciating the abilities of a computer system, but they may adopt so many new technologies that they do not have the time to fully utilize the new technologies.

The more statements a farmer generated for financial analysis, the more likely he was to adopt computerized record-keeping systems. Thus, farmers with a greater interest in record-keeping were likely to find the computer more useful because it can make financial analysis much easier compared to paper based records. This result was tested to see if the farmers with computerized record-keeping systems were generating more financial statements and that was not occurring in this study.

C. Implications

The effect of having a family successor highlighted that farmers are better managers if they plan on passing their farm down to a son or daughter. Extension may find a way to encourage those farmers without successors to manage their operations as if they were going to pass it down to a child. Extension could show farmers that even if they are not going to pass down the dairy, if it is managed well, the operation may be of a higher value when those farmers get ready to retire or sell out. Even though most of the selling price for a dairy is derived from the land and buildings, a well managed dairy can maintain and improve these facilities better than a poorly managed dairy.

Since this sample included farms that were above average producers and yet only 30% had adopted computerized record-keeping systems, extension personnel should create a program to help farmers set-up and learn how to keep their records on a computer. Advice guiding computer and software purchases and helping computerize previous years' records would go a long way to encourage the adoption of these systems.

D. Limitations of Thesis

A larger sample size would have allowed for more degrees of freedom in the models used and would likely have improved the significance of the independent variables in the models. The fact, however, that all Louisiana dairy farmers were contacted or contact was attempted, shows some of the research problems associated with a declining industry. The survey was designed to allow for the estimation of a profit figure for each individual farmer; however, it was impossible to get the necessary complete information to generate the profit figures.

E. Need for Further Research

This study should be expanded to include a larger geographic area so that a larger sample size would be possible and degrees of freedom would be less of a limiting factor when selecting models for the analysis. Also, it would be very useful to measure each farmer's net income and use an OLS regression model to examine what factors affected net income. In this way, extension personnel would have the ability to show farmers what technologies they could adopt that would actually increase profits.

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APPENDIX 1: QUESTIONAIRE FOR LOUISIANA DAIRY PRODUCERS 2005

How is your farm business structured?
Sole proprietorship   Partnership   Corporation   Other

How many times a day do you milk your cows? _______________

Land Use

How many acres of each category did you operate in 2005?

Corn	__________	Hay and Pasture	__________
Cotton	__________	Wooded Pasture	__________
Rice	__________	Woodland	__________
Soybeans	__________	Hogs	__________
Sugarcane	__________	Beef Cattle	__________
Wheat	__________	Goats	__________
Sorghum	__________	Sheep	__________
Silage Crops	__________	Chickens	__________
Other Crops	__________	Other	__________
Open Pasture	__________	Total	___________
Hay Only	__________		

How many acres of the total acres operated do you rent? _________________
What was your average lbs of milk/cow/year? 2005___________ 2004____________
What was your total lbs of milk produced per year? 2005_____________ 2004__________

What were your milk sales expenses for 2005 and 2004?

Marketing	$________________2005	$____________________2004
Hauling	$________________2005	$____________________2004
Cooperative retains	$________________2005	$____________________2004

Livestock Inventory

	Jan 04	# 04	Jan 05	Dec 05	# 05
Number of milking age cows					
Number of breeding bulls					
Number of cows that left the herd					
Culls					
Died					
Number of animals entering the herd					
Raised replacements					
Purchased replacements					
Bulls					
Total # of replacement heifers on hand					
Average age at first calving					
Calving interval					
Number of bull calves sold					
Number/percent of milking cows in milk					

Livestock Sales	Number Sold		Avg Weight	
Cull animal sales	2004	2005	2004	2005
2 day old calves	________	________	________	______
Cull 1-12 month heifer	________	________	________	______
Cull 12-24 month heifer	________	________	________	______
Cull 24+ month heifer	________	________	________	______
Cull bulls	________	________	________	______

Other livestock sales____
____
____

Cost of insect control and vet services

What method(s) of fly and pest control did you use in 2005?
Method 1______________ Months used____________________ Estimated total cost $__________
Method 2______________ Months used____________________ Estimated total cost $__________
Method 3______________ Months used____________________ Estimated total cost $__________
Method 4______________ Months used____________________ Estimated total cost $__________

Please describe your vaccination program:
____
____
____
____
____
____
____
____
____

What were your average annual costs on a total or per cow basis for the following expenses?

	2005	2004
Medication		
Veterinary Services		
Vaccines		
Veterinary Supplies		

Labor 2005 *each time

Item	Hrs Each Day	Days Each Month	Months Conducted	# Laborers
Daily milking of cows Including cleaning and roundup				
Daily checking of cows				
during breeding				
during calving				
Calving labor				
Hay feeding				
Supplemental grain feeding				
Silage Feeding				
Medication, worming				
Fly/pest control				
Other				
Other				

How much labor is available on your farm in the following categories?

	Number	Hours per week	% time devoted to the dairy operation
Operator			
Other family members			
Full time employees (<=30 hrs)			
Part time employees (>30hrs)			

How many hours per (week/month/year) are spent on fence and facility repair? _______________
Please list any other labor hours used for your dairy operation.

Hours/week	Activities
______________________	____________________________
______________________	____________________________
______________________	____________________________
______________________	____________________________

Growth Hormones

Did you administer or have someone else administer rGBH or another growth hormone to your dairy cattle? rGBH_____________ Other (please name) __________________________
What percent of the milking herd was included? ________________%
What was the frequency of treatments? __________________
What was the amount of treatments? ____________________
If you used an administrator, how much was their fee for each treatment? _____________

Do you use artificial insemination on any of your cows? __________________
If yes to artificial insemination, on approximately what percentage do you use AI?_______________

Feeding Practices (Milking Herd)

Please check the months in which you feed the following feeds to your milking herd:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Crop Residue												
Hay (type)												
Silage												
Concentrates												
Protein Supp												
Other (list)												
Other (list)												

Please describe the feeding method used for dairy cattle. Please list the machinery used and the number of hours the machinery is used per day during the months of feeding.

	Describe the feeding method	Machinery Used	Machine use per day (hours)
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			

When you feed the feeds listed above to dairy cattle, how much of each do you feed?

Amount	Hay	Silage	Concentrates	Protein	Other
Per head per day OR	lbs	lbs	lbs	lbs	Lbs
Per head per season OR	tons	tons	lbs	lbs	Lbs
Per head per season	tons	tons	tons	tons	tons

Feeding Practices (Dry Herd)

Please check the months in which you feed the following feeds to your dry herd:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Crop Residue												
Hay												
Silage												
Concentrates												
Protein Supp												
Other (list)												
Other (list)												

Please describe the feeding method used for dairy cattle. Please list the machinery used and the number of hours the machinery is used per day during the months of feeding.

	Describe the feeding method	Machinery Used	Machine use per day (hours)
Jan			
Feb			
Mar			
Apr			
May			
Jun			
Jul			
Aug			
Sep			
Oct			
Nov			
Dec			

When you feed the feeds listed above to dairy cattle, how much of each do you feed?

Amount	Hay	Silage	Concentrates	Protein	Other
Per head per day OR	lbs	lbs	lbs	lbs	Lbs
Per head per season OR	tons	tons	lbs	lbs	Lbs
Per head per season	tons	tons	tons	tons	tons

Forages *(Please fill out one sheet for each crop)*

Forage Crop__________________________ Acres _________________
Grazing or Harvesting purposes ________________________
Stocking rate_______________________________ (animals/acre)
Beginning and ending grazing dates: ____

Please provide the annual quantities of materials used per acre for this forage crop:

	Type	Amount/Acre/Year	No. Applications
Seed			
Nitrogen (lbs)			
Phosphate (lbs)			
Potash (lbs)			
Limestone (lbs)			
Herbicides			
Herbicides			
Other			
Other			

Please list the sequence of machine operations performed for this forage crop

Operation	Date	Times Over	Machine Type and Size	Tractor HP

Inventory, Housing, and Equipment

	Quantity	Size	Type	Replacement cost	Age
Dairy Parlor					
Milk tank					
Wash Down Area					
Permanent Fencing (miles)					
Temporary Fencing (miles)					
Hay Barns					
Shelter for Machinery					
Sick Pens (square feet)					
Corrals and Working pens					
Repair Shop					
Sewage Pond					
Other					
Other					

	Quantity	Size	Type	Age
Working/Squeeze Chute				
Cattle Trailers				
Automated Feed Bunks				
Grain Mixing & Handling Equip				
Feed Wagons				
Front-end Loaders				
Manure Spreaders				
Feedlots				
Pasture Mowers				
Hay Mowers				
Hay Conditioners				
Hay Rakes				
Hay Balers				
Hay Forks				
Disc				
Grain Drill				
Plow				
Soil Aerator				
Flatbed Trailers				
Other Hay Haulers				
Silos (type)				
Silage field choppers				
Silage blowers				
Pickup truck				
Tractor 1				
Tractor 2				
Tractor 3				
All terrain vehicle				
Silage wagons				
Hay feeding racks				
Feed bunks				
Cattle shelters (sq ft)				
Mineral/Supp feeder				
Other				

Demographic Information

Age_____ Sex_________

Level of Education? High school 2 yrs college undergrad degree masters doctorate

How many years in the dairy business? ________________

How many years in any type of farming? _______________

How much longer do you plan to run your dairy operation?________________

Do you have a close family member expected to take over the operation upon your retirement?-____

What percent of income is from off-farm sources? _____________%

What percent of farm income is from the dairy operation?___________%

Financial Records

Are financial records kept by farm business personnel or by an external professional?

Farm business personnel External professional

Do you use accounting professionals to report or prepare your taxes?_____ Other services? ____

If you have internal records, who keeps them?

Yourself partner spouse other family members hired help

Is your record keeping system manual or computer based? Manual Computer

How many hours per week are spent updating/maintaining and analyzing farm records? _______

How often are the farm records updated? Daily Weekly Monthly Yearly

Do you use a single or double entry accounting system? Single Double Don't know

Do you use a cash or accrual accounting system? Cash Accrual Don't know

Which financial statements do you use in your management activities?

Income Balance Sheet Cash Flows Owner's Equity All

Do you track your operation's

Liquidity ________ ability to meet obligations as they come due

Solvency ________ amount borrowed relative to equity

Profitability ________ amount of profit generated

Repayment Capacity ________ ability to repay debt from farm and non-farm income

Financial Efficiency ________ intensity of asset use

Computer Adoption

Do you own a computer? Yes No

If not, do you plan on buying one? Yes No

How long have you owned a computer? ___________________

Please rate how useful your computer is to your farm operation.

Not at all useful of Limited usefulness of moderate usefulness Very Useful

How many months passed between computer acquisition and the point where you felt it became a useful tool to you farm operation? ____________months

How many hours per week do you spend using the computer in any way that improves your information used in making management decisions? _______________hrs

Do you use a computer system designed for farms? Yes No

Did you design your own system using general software? Yes No

Have you had any formal computer training? Yes No

What software do you use in your operation? _______________________________________

Production Records

Please check the record keeping systems you have used or plan to adopt below.

	Have Used	Use Currently	Plan to Adopt
DHIA			
Automated Machinery Software			
Private Company Software			
Excel			
Spiral Notebook			
Other (specify)			

Do you plan to expand or contract the size of your operation over the next 5 years?

Expand Contract Neither By how much?____________(% or # cows)

How long have you used DHIA? __________________________

Do you use DHIA information in making everyday management decisions? Yes No

How many hours per week do you spend reviewing the DHIA output to improve your decision making process?____________

Please check the appropriate box if you have had any experience with the following technologies:

Technology	Positive	Negative	No Experience
Growth Hormones			
Automated Machinery Production Tracking			
Internet			
GPS			
Rotational Grazing			
Total mixed ration			

APPENDIX 2: LETTER MAILED OUT TO FARMERS

Date, 2006

Dear ______________,

Your dairy operation has been randomly selected to participate in a survey about the Louisiana Dairy Industry. This survey, conducted by the Louisiana State University Agricultural Center, is being done to update the annual dairy costs and returns estimates published by the Center. Your participation will aid in the budget reflecting the true economic state of the dairy industry to potential producers and other concerned individuals.

The survey will be administered by Elisabeth Grisham or Robert Boucher. They will contact you and schedule a time to come out to your farm and personally ask you the survey questions. Elisabeth is a graduate student at LSU and will use the survey results to write her M.S. thesis. Robert is a research associate with LSU. Along with updating the dairy budget, Elisabeth is also doing some research about technology adoption.

All data collected will be very confidential. Your name, address, and financial data will not be released to anyone for any reason. The survey data will be used only for analytical purposes.

We would like to thank you in advance for your cooperation. We hope through this survey to bring to you better and more relevant information to use in your decision making processes. If you have any questions, concerns or comments please feel free to contact Elisabeth Grisham at 1-870-219-9816 (cell), Robert Boucher 225-578-2767 or Dr. Jeff Gillespie at 225-578-2759. Thank you.

Sincerely

Dr. Jeffrey M Gillespie
Martin D. Woodin Regents Professor

Mrs. Elisabeth Grisham
Graduate Research Assistant

Robert Boucher
LSU Research Associate

VITA

Elisabeth Grisham was born and raised outside of Cave City, Arkansas, and attended elementary and high school there. She then attended Arkansas State University and received a bachelor's degree in accounting and agricultural business in May 2005. After obtaining her master's degree, she plans to become a CPA. In the future, Elisabeth hopes to become a farm management consultant.